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PATENT APPLICATION

of

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for a

INTERNAL BROADCAST RECEPTION SYSTEM FOR MOBILE PHONES

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INTERNAL BROADCAST RECEPTION SYSTEM FOR MOBILE PHONES

Field of the Invention

The present invention relates generally to an internal antenna for use in a hand-held device such as a mobile phone and, more particularly, to an internal reception system for receiving FM/digital broadcast signals.

Background of the Invention

It is known that frequency-modulation (FM) broadcast signals are commonly transmitted with carrier waves in the frequency range of 88-108 MHz. FM broadcasting is also referred to as very high frequency (VHF) radio broadcasting. To receive the FM broadcast signals, a quarter-wave antenna having a length in the order of 85 cm is required. In order to accommodate such a length, hand-held devices usually use external antennas, such as telescope-type antennas and head-set wires for FM broadcast reception. The major disadvantages of such external antennas are that they are visibly obtrusive and they increase the weight and the size of the hand-held device. In particular, when a mobile phone is equipped with an FM-broadcast reception system, it is undesirable to have an external antenna protruding out of the phone body, or to require the phone user to use a head-set in order to receive the FM broadcast signals.

It is thus advantageous and desirable to provide an internal antenna in a mobile phone for receiving FM broadcast signals. The same antenna can also be used to receive digital broadcast signals.

Summary of the Invention

It is a primary objective of the present invention to provide an internal FM/digital-broadcast reception system for use in a hand-held telecommunication device, such as a mobile phone. The entire reception system can be disposed within the housing of the mobile phone without external parts connecting to the reception system. The reception system is lightweight, cost effective, easy to produce, and can be easily interfaced with other mechanical and electronic components in the mobile phone. The above objective can be achieved by integrating an FM/digital antenna with necessary signal processing

electronics on a common substrate, which has a small size to be disposed entirely within the housing of the mobile phone.

Accordingly, the first aspect of the present invention is an integrated reception system for use in a hand-held telecommunication device for receiving frequency-modulation broadcast signals or digital broadcast signals, wherein the hand-held telecommunication device has a device body. The integrated reception system comprises:

an electrically non-conductive substrate located inside the device body;

an electrically conductive element, disposed on the substrate, for receiving the frequency-modulation broadcast signals or digital broadcast signals; and

a signal processing module disposed on the substrate and electronically connected to one end of the electrically conductive element, responsive to the received signals, for processing the received signals.

According to the present invention, the hand-held telecommunication device includes a chassis for disposing telecommunication components. The substrate can be a part of the chassis or a separate part but mechanically and electrically connected to the chassis.

According to the present invention, the electrically non-conductive substrate can be rigid or flexible.

According to the present invention, the electrically conductive element may have a meandering pattern in order to reduce the size of the electrically non-conductive substrate.

According to the present invention, the electrically conductive element may be wound around the electrically non-conductive substrate so as to reduce the physical size of the electrically conductive element and, therefore, the size of the electrically non-conductive susbstrate.

According to the present invention, the signal processing module may include a band-tune circuit for selecting a frequency band.

According to the present invention, the signal processing module may include an active amplifier to amplify the received signals.

According to the second aspect of the present invention, a mobile phone capable of receiving broadcast signals. The mobile phone comprises:

a housing; and

an integrated reception system, disposed within the housing, wherein the reception system comprises:

an electrically non-conductive substrate located inside the housing;

an electrically conductive element, disposed on the substrate, for receiving broadcast signals; and

a signal processing module disposed on the substrate and electronically connected to one end of the electrically conductive element, responsive to the received signals, for processing the received signals.

According to the present invention, the broadcast signals are frequency-modulated broadcast signals, and the signal processing module may include a tuning circuit for selecting a channel and a demodulating device for converting the broadcast signals to audio signals.

According to the present invention, the broadcast signals are digital broadcast signals and the hand-held telecommunication device includes a digital signal processing device for selecting a channel from the broadcast signals and for controlling a gain of the broadcast signals.

The present invention will become apparent upon reading the description taking in conjunction with Figures 1a to 7.

Brief Description of the Drawings

Figure 1a is an exploded view of a mobile phone showing a chassis in the housing of the mobile phone, wherein the integrated FM/digital broadcast reception system is disposed on the chassis.

Figure 1b is an exploded view showing the integrated FM/digital broadcast reception system being separated from the chassis, wherein the reception system has a rigid substrate.

Figure 1c is an exploded view showing a flexible substrate.

Figure 2a is a diagrammatic representation illustrating an antenna and a pre-processing module being disposed on the same side of the substrate.

Figure 2b is a diagrammatic representation illustrating the antenna and the pre-processing module being disposed on opposite sides of the substrate.

Figure 2c is a diagrammatic representation illustrating the antenna and the pre-processing module being disposed on a flexible substrate.

Figure 2d is a diagrammatic representation illustrating the antenna being disposed on both sides of the substrate.

Figure 2e is a diagrammatic representation illustrating a coil-like antenna.

Figure 3 is a block diagram illustrating a plurality of electrical components in the pre-processing module.

Figure 4a is a block diagram illustrating the connection between the integrated digital broadcast reception system and a common part of the mobile phone.

Figure 4b is a block diagram illustrating the connection between the integrated analog broadcast reception system and a common part of the mobile phone.

Figure 5a is a circuit diagram illustrating a fixed band-tuning circuit.

Figure 5b is a circuit diagram illustrating a variable band-tuning circuit.

Figure 6a is a circuit diagram illustrating a signal amplifier circuit.

Figure 6b is a circuit diagram illustrating a signal amplifier circuit having a gain control element.

Figure 7 is a circuit diagram illustrating an impedance matching circuit.

Detailed Description of the Invention

The basic components of the integrated FM/digital broadcast reception system **1**, according to the present invention, include an antenna **10** directly connected to a pre-processing module **20**. The antenna **10** and pre-processing module **20** are disposed on a substrate **5**, as shown in Figures 2a and 2b. The antenna **10** can be printed on the substrate **5** or etched out from a ground plane **60** of a printed circuit board (PCB) or a printed wire board (PWB). As such, the integrated reception system **1** is easy to produce and install in a hand-held telecommunication device such as a mobile phone **100**, as shown in Figures 1a - 1c.

As shown in Figures 1a - 1c, the mobile phone **100** has a phone body or housing **110**, and a chassis **120** on which some or all electronic telecommunication components are disposed. For example, a microprocessor or ASIC is usually disposed on the chassis **120**, along with a display, a SIM card reader, memory, battery and so on. The chassis is not part of the invention. The substrate **5** for accommodating the antenna **10** and the pre-

processing module **20** can be an integral part of the chassis **120**, as shown in Figure 1a. This means that the antenna **10** can be printed on the chassis together with the connecting wires and other electrically conductive parts. Alternatively, the antenna **10** can be etched out from the ground plane of the chassis.

The substrate **5** can also be a base material separate from the chassis, as shown in Figure 1b. In that case, the antenna **10** and the pre-processing module **20** are produced or assembled on the substrate **5**, and the substrate **5** is then mechanically and electronically connected to the chassis **120** in a separate assembling process. The substrate **5** can be a rigid piece of base material, as shown in Figure **1b**. Alternatively, the substrate **5** can be a flexible piece of electrically non-conductive polymer or the like, as shown in Figure 1c. A flexible substrate, even with the pre-processing module **20** disposed thereon, can be folded (Figure 2c) or twisted to fit in some small extra space within the housing **110**. As shown in Figures 2a and 2b, a signal connector **50** is also provided so that pre-processed signals **78** can be conveyed to the chassis **120** of the mobile phone **100**. Additionally, a power connector **52** is provided to bring power **80** to the pre-processing module **20**. As shown in Figure 2c, the substrate **5** is flexible such that it can be rolled up into a small volume. As shown in Figure 2d, the antenna **10** is wound around the substrate **5** to form a helix occupying both sides of the substrate **5**. Similarly, the antenna **10** can be disposed on the substrate **5** as a coil and the like, as shown in Figure 2e. The objective of the present invention is to reduce the physical size or dimension of the antenna **10** and that of the substrate **5**. If the frequency of the carrier waves is 88 MHz, then the wavelength of carrier waves is approximately 341 cm. With the present invention, the physical size of the antenna **10** and that of the substrate **5** can be made much smaller than the quarter-wavelength, or 85 cm (33.46 inches).

As shown in Figure 2a, the pre-processing module **20** and the antenna **10** are disposed on the same side **6** of the substrate **5**. However, they can be disposed on different sides of the substrate **5**, as shown in Figure 2b. As shown in Figure 2b, while the antenna **10** is provided on one side **7** of the substrate **5**, the pre-processing module **20** is mounted on the opposite side **6**. The antenna **10** can be etched out from an existing ground plane **60** of the substrate **5**.

The pre-processing module **20** is disposed together with the antenna **10** on the substrate **5** so that band-tuning and active amplification can be carried out on the same

substrate. An exemplary circuit of the pre-processing module is shown in Figure 3. As shown in Figure 3, in order to process received broadcast signals **84** (in radio frequency) from the antenna **10**, the pre-processing module **20** includes a band-tuning circuit **22**, an active amplification circuit **24**, and an impedance matching circuit **26**. Preferably, the antenna **10** is tuned by the band-tuning circuit **22** so that the antenna **10** pre-selects all stations in the FM frequency band of 88-108 MHz. The band-tuned signals are denoted by reference numeral **86**. Exemplary band-tuning circuits are shown in Figures 5a and 5b. An exemplary active amplification circuit **24** is shown in Figure 6a. The amplified signals are denoted by reference numeral **88**. The impedance matching circuit **26** can simply be a capacitor 76, as shown in Figure 7. The output from the pre-processing module **20** is denoted by reference numeral **90**.

The present invention advantageously makes use of existing components of a typical mobile phone. In a digital phone, as shown in Figure 4a, existing components **200** that can be used for further processing the pre-processed signals **90** includes a digital signal processor (DSP) **210**, a speaker **220** and a power supply **230**. For example, the signals **90** are directly fed to an analog-to-digital converter (A/D) inside the DSP **210**. The DSP **210** is also used for channel selection and demodulation. Additionally, the DSP **210** can be used to generate a tuning voltage $\mathbf{V_T}$ for band-tuning and a gain-control voltage $\mathbf{V_G}$ to control the gain of the active amplification circuit **24**. The output **92** (in audio frequency) from the DSP **210** is then conveyed to the speaker **220** to produce audible sound. The power supply **230** of the mobile phone **100** can also be used to provide power $\mathbf{V_{cc}}$ to the pre-processing module **20**. Preferably, the power $\mathbf{V_{cc}}$ is provided to the pre-processing module **20** only when the mobile phone **100** is switched to the broadcast receiving mode. The power $\mathbf{V_{cc}}$ provided to the pre-processing module **20** is turned off by a switch **240** during a call. The power $\mathbf{V_{cc}}$ provided to the pre-processing module **20** can also be switched off when the mobile phone **100** is not used to receive broadcast signals to save power.

When the mobile phone **100** is used to receive analog broadcast signals, additional components **300** are needed. As shown in Figure 4b, a channel selection tuner **310** allows a user to select a channel from the pre-processed signals **90**. The radio frequency signals **94**, as selected by the channel selection tuner **310**, are down-converted into audio signals **96** by a demodulation module **320**. As it is known in the art, the demodulation module

320 may comprise a local oscillator, mixer, one or more intermediate stages, demodulator and so forth. The audio frequency signals **96** are further processed by an amplifier **212** before being conveyed to the speaker **220**. The amplifier **212**, the speaker **220** and the power supply **230** are the audio components **202** commonly found in a mobile phone **100**.

As shown in Figure 4b, the channel is selected by applying a tuning voltage $\mathbf{V_T}$, via an external control **330**. Preferably, the gain control voltage $\mathbf{V_G}$ is provided by an automatic gain control unit (AGC), which is not shown. The band-tuning voltage $\mathbf{V_T}$, however, should be provided in the manufacturing process.

It is possible that an antenna of a selected size can be used with a resonance circuit to select the frequency band. For example, an LC circuit, as shown in Figure 5a, having a fixed inductor **60** and a fixed capacitor **62** can be used for band-tuning. However, antennas in different mobile phones can be of different sizes. Thus, these antennas must be tuned for band selection. For that purpose, it is possible to add a varicap **64** in the LC circuit, as shown in Figure 5b so that antennas of different sizes can be used with a similar pre-processing module **20**. In order to tune the antenna **10**, a band-tuning voltage $\mathbf{V_T}$, generated by the DSP **210**, is fed to the varicap **64** via a resistor **66**, as shown in Figure 5b.

Figure 6a shows an exemplary signal amplification circuit **24**. As shown in Figure 6a, an FET **72** and two resistors **70** and **74** are used to form a single-stage amplifier. In Figure 6a, $\mathbf{Z_{in}}$ denotes input impedance of the amplifier. If necessary, an output impedance $\mathbf{Z_{out}}$ is provided with a capacitor **76**, as shown in Figure 7, such that $\mathbf{Z_{in}} >> \mathbf{Z_{out}}$. It is preferred that the capacitor **76** is located within the DSP **210**. Because the output impedance $\mathbf{Z_{out}}$ of the FET stage depends also on the drain resistor **74**, it is possible to vary the drain resistor **74** to adjust the output impedance $\mathbf{Z_{out}}$. Furthermore, it is possible to vary the amplification factor or gain of the signal amplification circuit **24** by feeding the gain-control voltage $\mathbf{V_G}$ to a capacitor **71** connected between the gate resistor **70** and the ground, as shown in Figure 6b.

The additional components **300** can be disposed on the substrate **5**, or on the chassis **120**.

In summary, the present invention integrates an FM broadcast reception system inside a hand-held telecommunication device, such as a mobile phone. The FM antenna

is not protruding outside of the phone body. The present invention makes reception of FM broadcast possible without using any external parts. The antenna is lightweight and cost-effective. By disposing the antenna on a substrate inside the phone body, the necessary mechanical and electrical interfacing to the phone is greatly simplified. As it is known, the FM broadcast uses the frequency range of 88 MHz -108 MHz, so as the basic digital broadcasting system. The physical size of the antenna and the substrate of the present invention is much smaller than the quarter-wavelength of the received signals in that frequency range. However, the present invention is also applicable to other frequency ranges as well. For example, the internal broadcast reception system for the present invention is also used to receive the broadcast in the 53 MHz - 99 MHz, or the digital broadcast around 200 MHz.

Thus, although the invention has been described with respect to a preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and various other changes, omissions and deviations in the form and detail thereof may be made without departing from the spirit and scope of this invention.